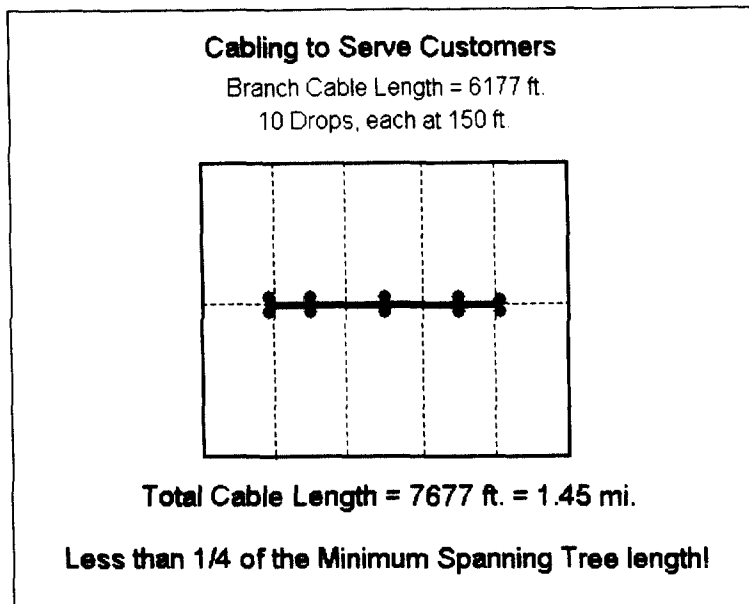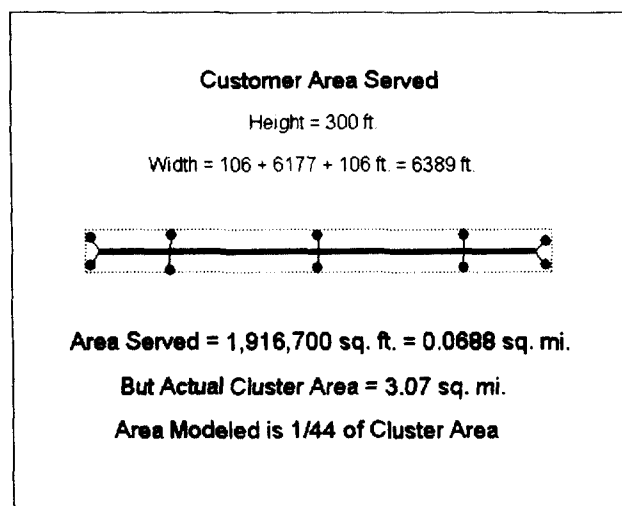In this example, there is no backbone cable, only a branch cable. The DLC site is at the centroid of the rectangular cluster. 150-ft. drops connect to the customers.

Cabling to Serve Customers

Branch Cable Length = 6177 ft.

10 Drops, each at 150 ft.

Total Cable Length = 7677 ft. = 1.45 mi.

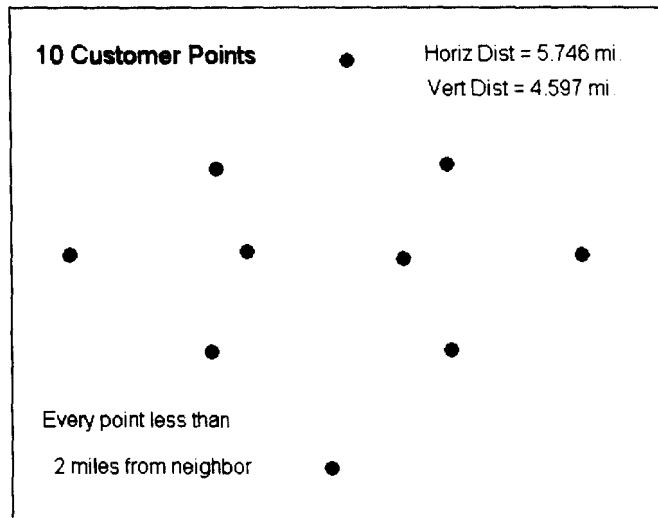**Less than 1/4 of the Minimum Spanning Tree length!**

But note how closely the customers are squeezed toward the branch cable. The arrangement is unrealistic, both from the standpoint of cable length *and* from the standpoint of area served.

Customer Area Served

Height = 300 ft.

Width = 106 + 6177 + 106 ft. = 6389 ft.

Area Served = 1,916,700 sq. ft. = 0.0688 sq. mi.

But Actual Cluster Area = 3.07 sq. mi.

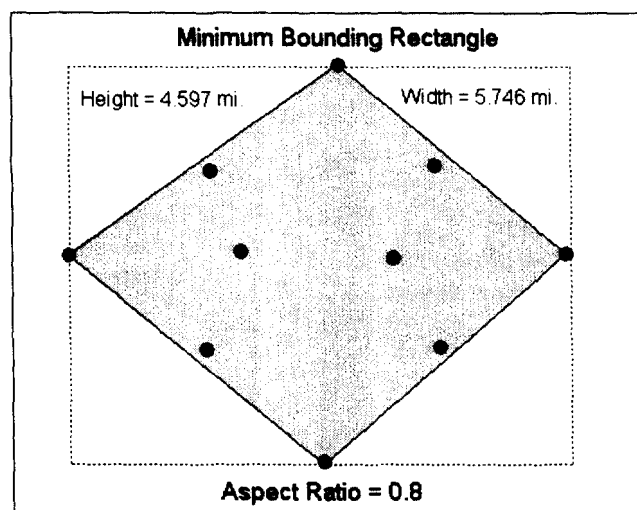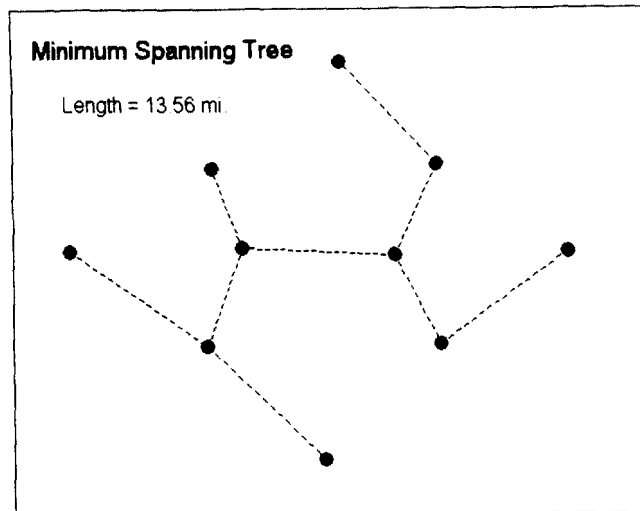**Area Modeled is 1/44 of Cluster Area**

Hence, for this example, the distribution plant route miles modeled by HAI 5.0a are only 25 % of the minimum amount required to connect the 9 customers in their "actual" locations. Moreover, the area modeled as containing distribution plant is only 2 % of the area of the polygon (convex hull) cluster.
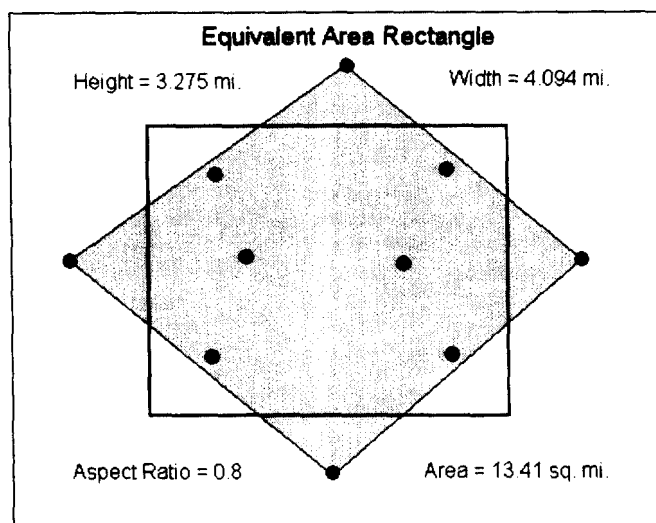
Example #2

The next example considers a much larger cluster, similar in size and density to which HAI 5.0a models in low-density areas.

Minimum Spanning Tree

Length = 13.56 mi.

Minimum Bounding Rectangle

Height = 4.597 mi.   Width = 5.746 mi.

Aspect Ratio = 0.8

Convex Hull of Cluster — Area = 13.41 sq. mi.

Equivalent Area Rectangle — Height = 3.275 mi., Width = 4.094 mi., Aspect Ratio = 0.8, Area = 13.41 sq. mi.

Constructed Lots

Each Lot Width = 0.819 mi.   Each Lot Height = 1.638 mi.

Constructed Customer Locations and Cabling

Each customer at 150 ft. drop from branch cable

Total cable length = (3 x 0.819) + (10 x 150/5280) = 2.74 mi.

(Minimum Spanning Tree is 13.56 mi.)

Total Customer Area Served

300 ft. x (106 ft. + (2.457 mi. x 5280) + 106 ft.) = 3,955,488 sq. ft.
= 0.142 sq. mi.

Area of the Cluster is 13.41 sq. mi.

Area Served is 1/94 of the Cluster Area
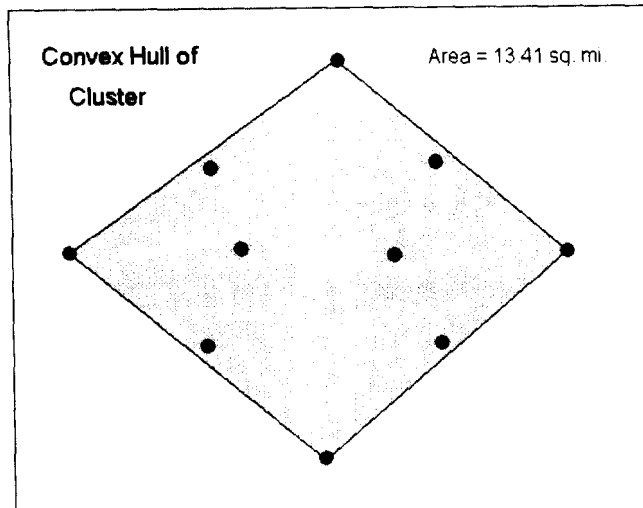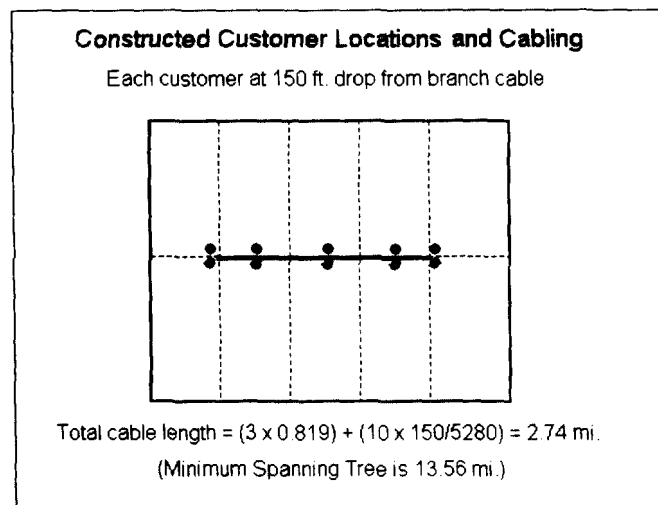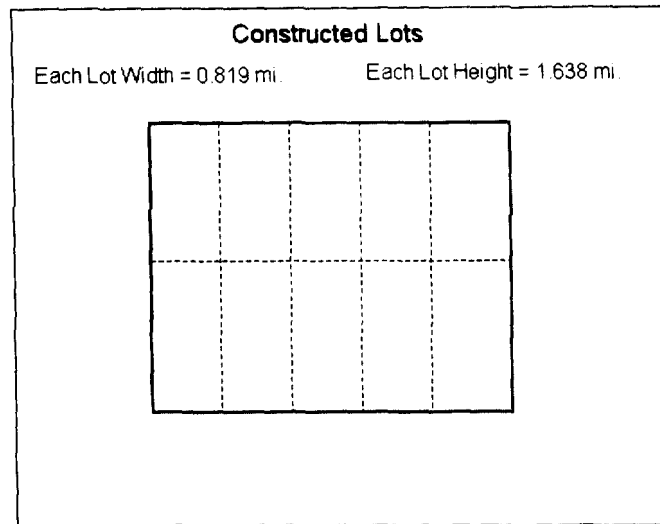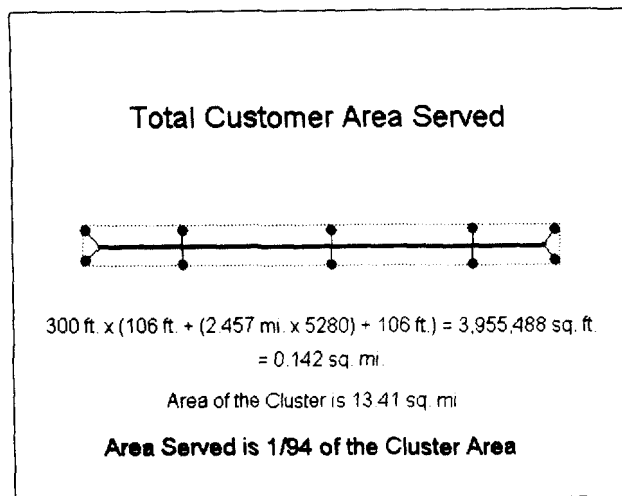
Hence, in this example, the distribution plant modeled by HAI 5.0a is only 20 % of the minimum amount necessary to serve these 9 customers in their "actual" locations. Moreover, the area that contains distribution plant represents only 1 % of the total area of the polygon cluster of "actual" locations.
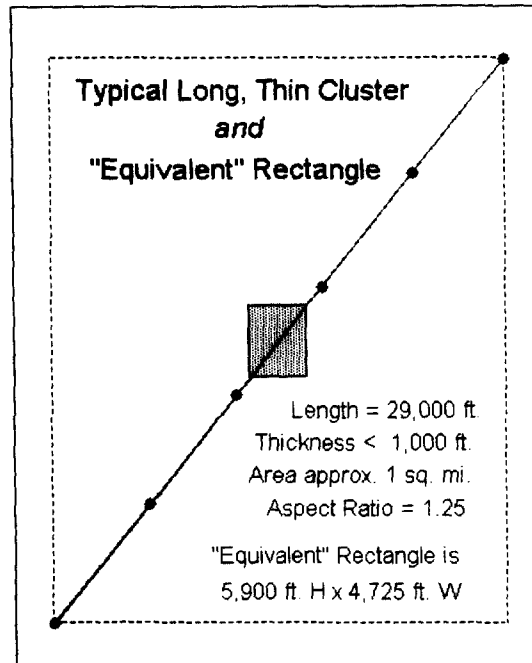
Example #3

An extreme case occurs when the convex hull cluster is long and thin. This commonly occurs in rural areas where Census Blocks tend to be large and the roads tend to be long. Thus, the distance constraints employed by the HAI clustering algorithm tend to group together *strings* of subscribers along a several mile segment of road. Sometimes the road is straight, sometimes it is curved, and sometimes it bends. But very typically, the convex hull of the resulting cluster is long and skinny.

The figure below shows a long and thin convex hull cluster that can occur in rural areas. The cluster consists of 6 locations strung out along a relatively straight line (road). The length of this string is 29,000' with a width of less than 1,000'. The minimum bounding rectangle for this cluster is also shown and is assumed to have an aspect ratio of 1.25. In this example, the equivalent area rectangle has an area of approximately 1 square mile.

Typical Long, Thin Cluster
and
"Equivalent" Rectangle

Length = 29,000 ft.
Thickness < 1,000 ft.
Area approx. 1 sq. mi.
Aspect Ratio = 1.25

"Equivalent" Rectangle is
5,900 ft. H x 4,725 ft. W

Assuming 6 locations in this cluster yields 6 plots, each 0.17 square miles in size. The HAI distribution module algorithm then assumes each lot is twice as deep as it is wide. This yields lots that are 3,048' deep and 1,524' wide.[4]

HAI 5.0a conceptually models this cluster as consisting of 2 rows of lots (East-West). Since twice the lot depth exceeds the North-South dimension
of the cluster, HAI 5.0a defaults to no backbone cable with to two East-West branch cables emanating from the DLC. The cable extends for only 1,524', the width of one lot. Assuming 150 ' drops yields a total route distance of 2,424'.[5]

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[4] Note that the HAI algorithm is not consistent with respect to the aspect ratio of lots versus the aspect ratio of the equivalent area rectangular cluster. The aspect ratio of a lot is independent of the aspect ratio of the rectangular cluster and is always 2. Thus, in this example, the sum of the lot depths (3,048' x 2 = 6,096') exceeds the "depth" of the rectangular cluster (5,900').

[5] HAI 5.0a actually models 1,674' of branch cable for this cluster. In calculating the branch cable length, HAI 5.0a refers to the aspect ratio for the rectangular cluster despite its inconsistency with the lot aspect ratio of 2 (see Distribution Module.xls, Calculations Sheet, column W).

In other words, HAI 5.0a assumes that only 2,424' of cable is required to serve 6 customers who are actually identified by HAI as being strung out along a road 29,000' in length. Since the 6 customers are assumed to be essentially in a straight line, 29,000' *is* the minimum spanning tree distance. Hence, HAI 5.0a places only 8.4 % of the cable necessary to serve these customers in their locations within the convex hull.

Summary: Our analysis indicates that there are two effects that work together to lower the amount of distribution plant calculated by HAI 5.0a in rural, low-density areas.

The first effect results from the distortion of the original polygon cluster of "actual" customer locations caused by the formation of the rectangular clusters. The distortion results from the rectangular clusters having the aspect ratio of the minimum bounding rectangle of the polygon cluster and the area of the polygon cluster.

The second effect results from the branch and backbone cable length algorithm that essentially forces customer premises to be concentrated around the center lot(s) of the cluster. This results from the requirement that the backbone and branch cables extend no further than one lot depth (width) from the rectangle cluster's boundary. This constraint has the greatest effect on distribution route distance in large, low-density clusters where the individual lots are very large.

The bottom line conclusion is that HAI 5.0a is not placing enough distribution cable to serve customers in their "actual" locations, as identified by PNR's polygon clusters. This underplacement appears to be the most severe in the low-density clusters.

CERTIFICATE OF SERVICE

I, Kelseau Powe, Jr., do hereby certify that on this 25th day of June, 1998, I have caused a copy of the foregoing **COMMENTS OF U S WEST COMMUNICATIONS, INC. ON STATE FORWARD-LOOKING COST STUDIES FOR UNIVERSAL SERVICE SUPPORT** to be served, via United States Mail, postage pre-paid, upon the persons listed on the attached service list.

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*William E. Kennard
Federal Communications Commission
Room 814
1919 M Street, N.W.
Washington, DC 20554

*Gloria Tristani
Federal Communications Commission
Room 826
1919 M Street, N.W.
Washington, DC 20554

*Michael K. Powell
Federal Communications Commission
Room 844
1919 M Street, N.W.
Washington, DC 20554

*Harold Furchtgott-Roth
Federal Communications Commission
Room 802
1919 M Street, N.W.
Washington, DC 20554

*Susan P. Ness
Federal Communications Commission
Room 832
1919 M Street, N.W.
Washington, DC 20554

*Kathryn C. Brown
Federal Communications Commission
Room 500
1919 M Street, N.W.
Washington, DC 20554

*Lisa Gelb
Federal Communications Commission
8th Floor
2100 M Street, N.W.
Washington, DC 20554

*Sheryl Todd
Federal Communications Commission
8th Floor
2100 M Street, N.W.
Washington, DC 20554

(3 copies)

*Bryon Clopton
Federal Communications Commission
8th Floor
2100 M Street, N.W.
Washington, DC 20554

*Katie King
Federal Communications Commission
8th Floor
2100 M Street, N.W.
Washington, DC 20554

(Including 3x5 inch diskette w/cover letter)

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1231 20th Street, N.W.
Washington, DC 20036

Milton Y. Higa
Hawaii Public Utilities Commission
Room 103
465 South King Street
Honolulu, HI 96813

Kevin O'Grady
Minnesota Public Utilities Commission
Suite 350
121 7th Place East
St. Paul, MN 55101-2147

Chairperson
Public Service Commission of the
 State of Montana
1701 Prospect Avenue
POB 202601
Helena, MT 59620-2601

Lowell C. Johnson
Nebraska Public Service Commission
300 The Atrium
1200 N Street
Lincoln, NE 68508

Judy Hunt
William R. Pittman
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State of North Carolina
 Utilities Commission
POB 29510
Raleigh, NC 27626-0510

Chairperson
Telecommunications Regulatory Board
 of Puerto Rico
Government of Puerto Rico
Suite 901
Capital Center, North Tower
235 Arterial Hostos Avenue
San Juan, PR 00918-1453

Michael S. Pabian
Ameritech
Room 4H82
2000 West Ameritech Center Drive
Hoffman Estates, IL 60196-1025

Chairperson
Kentucky Public Service Commission
730 Schenkel Lane
POB 615
Frankfurt, KY 40602

Chairperson
Louisiana Public Service Commission
POB 91154
Baton Rouge, LA 70821-9154

Chairperson
Illinois Commerce Commission
527 East Capital Avenue
POB 19280
Springfield, IL 62794-9280

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South Carolina Public Service
  Commission
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Columbia, SC 29211

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